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Improving Knowledge, Inputs and Markets for Legume Expansion: A Contribution Analysis of N2Africa in Ghana and Ethiopia

Giel Ton and Dominic Glover
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Foreword

As N2Africa moved into its tenth and final year, my project colleagues and I were busy with impact studies. These comprised a number of formal, large-scale, questionnaire-based evaluations, which specifically addressed the impacts of our efforts at farm household level. Talking to my colleagues, I became increasingly concerned that the household surveys would not capture important learnings from the project. I was thinking about how best we could capture other kinds of outcomes and learnings.

Impact studies based on survey questionnaires are the standard tool for looking at changes at household level, but they have some shortcomings. They provide snapshots of the situation at a specific moment in time, although we know that 'adoption' cannot be understood simply as an on–off switch. At the same time, in N2Africa we tried to get messages out as widely as possible – in effect, we were intentionally 'contaminating' any potential control group of households. Further, we had coordinated interventions at so many levels across the value chain that I was concerned they could not be captured by household surveys.

I discussed these concerns with my colleague and collaborator, IDS Fellow Jim Sumberg, when he was visiting my group in Wageningen. I suggested that one way to try and understand the broader impacts of N2Africa could be to test each of the assumptions made between the steps of the project's Theory of Change. Jim responded: 'But that sounds like Contribution Analysis – an established method that is used by my colleague Giel Ton.'

That is how the N2Africa team came to work with Giel and Dominic Glover on the two case studies presented in this report. There is no doubt that with Contribution Analysis we have learned more about the outcomes and impacts of actions taken by N2Africa over the past years. We benefit from having our work held up to the light for critical examination, and this report provides a most useful complement to the other impact studies that are currently underway.

I commend the Contribution Analysis approach to you – and will certainly try and use it in a more concerted way in other ongoing and future projects.

Ken Giller
N2Africa Project Lead
Professor of Plant Production Systems
Wageningen University

Improving Knowledge, Inputs and Markets for Legume Expansion: A Contribution Analysis of N2Africa in Ghana and Ethiopia

Giel Ton and Dominic Glover

Summary

This report documents the findings of an evaluation study of the impacts of N2Africa, a ten-year 'research-in-development' project that aimed to harness nitrogen fixation for the benefit of small-scale farmers of legume crops. The study analysed N2Africa's contribution to development outcomes using the methodology of process tracing as a structured way of critically reviewing the change process.

The evaluation focused on N2Africa's activities in Ghana and Ethiopia. In Ghana, the evaluators examined the evidence base underlying the contribution claim, 'N2Africa has been a relevant contributory factor in the expansion of soybean production in northern Ghana'. In Ethiopia, they verified the claim that 'N2Africa has contributed to the increase in production, distribution, uptake and expansion of market demand for legume inoculants'. The evaluation identified the critical causal assumptions underlying the project's Theory of Change in each case. After reviewing available project documentation and other literature, additional data were gathered through stakeholder interviews. The study sought to verify whether the expected changes had taken place, and assessed the size and importance of N2Africa's contribution to each of the observed outcomes.

The study found convincing evidence that N2Africa contributed substantially to a process of technological upgrading of soybean production in northern Ghana, yet the project played a relatively small part in the overall increase in soybean production in that region. In Ethiopia, there was clear evidence that N2Africa had made a decisive contribution to expanding the production and supply of legume inoculants, and had stimulated awareness of and demand for inoculants among small numbers of legume farmers. However, the project has only helped the market for legume inoculants to reach a small fraction of its potential.

Keywords: impact evaluation; technological change; legumes; rhizobium; input markets.

Giel Ton is a social scientist at the Institute of Development Studies and Director of the Centre for Development Impact. He specialises in the design of mixed-methods impact evaluations in agricultural value chains and private sector development, and applies Contribution Analysis as an overarching approach. His previous research has focused on contract farming, collective marketing, innovation grants, and certification.

Dominic Glover is an interdisciplinary social science researcher specialising in technology, agriculture and agrarian change. His previous research has focused on the emergence and spread of new technologies, cultivation methods and farming practices through small-scale agricultural systems, including transgenic crops and alternative methods of rice cultivation.

Executive summary

The N2Africa project was a ten-year 'research-in-development' project, which aimed to harness nitrogen fixation for the benefit of African small-scale farmers of legume crops. The key productivity-enhancing technologies promoted by N2Africa were improved legume varieties in conjunction with fertilisers and rhizobium inoculants. Rhizobia are living organisms that have a symbiotic relationship with leguminous plants and fix nitrogen from the atmosphere. The project also worked to strengthen value chains and improve legume farmers' access to input and output markets.

N2Africa gathered and monitored information about the impact of its work. However, the diversity of N2Africa's interventions, their dynamism, and the widely different contexts where these have been implemented, make it challenging to derive strong inferences about the project's impacts from survey-based impact evaluations. Therefore, N2Africa also used institutional information and community-level data collected using qualitative methods.

N2Africa's objective was to construct a coherent and evidence-based contribution narrative – in other words, a narrative that explains and demonstrates how the project's activities contributed to the impacts indicated in the Theory of Change. The aim of this type of analysis is to support those involved in a project to develop a fuller understanding of what they had achieved, and to construct more refined Theories of Change that may be used to scale and replicate interventions in the future.

To assist N2Africa with this effort, a team of external evaluators from the Institute of Development Studies (IDS, Brighton, UK) gathered and critically analysed evidence underlying N2Africa's claims about its impact. The evaluation team used an approach known as Contribution Analysis. This approach is informed by the methodology of process tracing, which is a structured way of critically reviewing a process and sequence of change.

The evaluation focused on two case studies, in Ghana and Ethiopia respectively, which were considered by N2Africa stakeholders to be promising for replication or upscaling. After reviewing available project documentation and other literature, the evaluation proceeded by first identifying critical assumptions underlying the Theory of Change. The evaluation team then gathered additional data through stakeholder interviews. The interviews were used alongside the documentary evidence to verify whether the expected changes had indeed taken place, and assessed the size and importance of N2Africa's contribution to each of these outcomes.

In the Ghana case, the evaluators examined the evidence base underlying the contribution claim, 'N2Africa has been a relevant contributory factor in the expansion of soybean production in northern Ghana'. In Ethiopia, they verified the claim that 'N2Africa has contributed to the increase in production, distribution, uptake and expansion of market demand for legume inoculants'.

This report documents the evaluation process and summarises the findings. The study found convincing evidence that N2Africa contributed substantially to

a process of technological upgrading of soybean production in northern Ghana, which, however, is still only weakly contributing to the expansion of soybean production in that region. In Ethiopia, there was clear evidence that N2Africa had made a decisive contribution to expanding the production and supply of legume inoculants, and had stimulated awareness of and demand for inoculants among small numbers of legume farmers. However, stakeholders believe that the market for legume inoculants has only reached a small fraction of its potential.

Contents

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Acronyms

AGRA	Alliance for a Green Revolution in Africa
BMGF	Bill & Melinda Gates Foundation
CRS	Catholic Relief Services
EPDRA	Evangelical Presbyterian Development and Relief Agency
HARC	Hollota Agricultural Research Centre (Ethiopia)
ILRI	International Livestock Research Institute
MBI	Menagesha Biotech Industry (Ethiopia)
NARS	National Agricultural Research System (Ethiopia)
NGO	non-government organisation
NPK	nitrogen, phosphorus, potassium
NSTC	National Soil Testing Centre (Ethiopia)
P-fertiliser	Fertiliser with a phosphorus component
PFJ	Planting for Food and Jobs (Ghana)
PPP	public–private partnership
R&D	research and development
SSTP	Scaling Seeds and Technologies Partnership (AGRA)
TSP	triple superphosphate
USAID	United States Agency for International Development

1 Introduction

The N2Africa project was a ten-year 'research-in-development' project, which aimed to harness nitrogen (N_2) fixation for the benefit of African small-scale farmers of legume crops. The project carried out a number of interlinked activities in several countries, including Ghana and Ethiopia, to improve the lives of smallholders by increasing the productivity of legume cultivation. The key productivity-enhancing technologies promoted by N2Africa were improved legume varieties in conjunction with fertilisers and rhizobium inoculants. Rhizobia are living organisms that have a symbiotic relationship with leguminous plants, and fix nitrogen from the atmosphere. The project also worked to strengthen value chains and improve legume farmers' access to input and output markets.[1]

N2Africa gathered and analysed data to monitor its progress and study the impact of its activities. The project team's principal approach to quantitative evaluation was the matched difference-in-difference survey, a method that compares the situations before and after N2Africa's intervention, for the groups targeted by the project and one or more control groups. The project team also gathered institutional information and community-level data, using qualitative methods. Together, the quantitative and qualitative data were intended to provide evidence that would show whether and how N2Africa may have contributed to the impacts envisaged in the project's Theory of Change. Because N2Africa made a range of different interventions, and implemented them flexibly and dynamically across a broad spectrum of African contexts, it proved challenging to derive generalised inferences about the project's impacts using monitoring information and survey-based quasi-experimental designs.

As an additional impact evaluation method, N2Africa appointed us, the authors, as external evaluators, to critically analyse the evidence behind claims that N2Africa contributed to the impacts envisaged in the project's Theory of Change, and reflect on the contextual conditions and causal mechanisms that led to the project's outcomes. We introduced and applied the methodology of Contribution Analysis (Mayne 2001; Mayne 2011; Ton 2017) to test and reflect on the project's Theory of Change, learn lessons, and develop more refined theories that could be used in the future to replicate successful activities and to scale up and out.

We worked as external evaluators and had not been involved in N2Africa before; however, we worked closely with N2Africa researchers and staff. We used N2Africa's documentation as major sources of information, and the project team members as the key informants who were most knowledgeable about the project, most keenly interested in it, and best placed not only to reflect on its successes and failures but to consider the emerging findings of the Contribution Analysis, and to learn lessons from the conclusions.

In two case studies, we used an analytical approach informed by process tracing (Punton and Welle 2015; Beach and Pedersen 2013; Befani and Mayne 2014). Process tracing offers a structured way to verify causal inferences, by critically

1 See www.n2africa.org.

reviewing the process and sequence of change. The analysis begins by inferring the existence of a causal claim, by reviewing programme documents and eliciting the (implied) Theory of Change. Then, we gathered additional data through stakeholder interviews, to verify whether the claimed outcomes were indeed delivered, and whether the project can be considered a necessary (non-redundant) contributory factor in these change processes. Finally, we used the available evidence to characterise the strength of the contribution claims, using 'hoop tests' (Figure 1.1). The figure illustrates the approach and indicates that a stronger contribution claim is linked to the passing through a smaller (more stringent) hoop. The hoop tests are 'counterfactual thought experiments', based on rigorous logical reasoning (Belkin and Tetlock 1996).

Figure 1.1 Hoop tests to assess the strength of the contribution claim

Source: Authors' own.

In each case study, stakeholder interviews were used to answer five generic questions, which were designed to assess the strength of the contribution claim made by N2Africa:

- Did the change occur?
- Did it result from a process in which N2Africa support was used?
- Can this support be considered as a necessary (non-redundant) causal factor for that process to have taken place?
- If not, was it a necessary causal factor in accelerating or scaling of the outcomes?
- Were there any other institutions or programmes that may have provided similar support to the change process, if N2Africa had not been present?

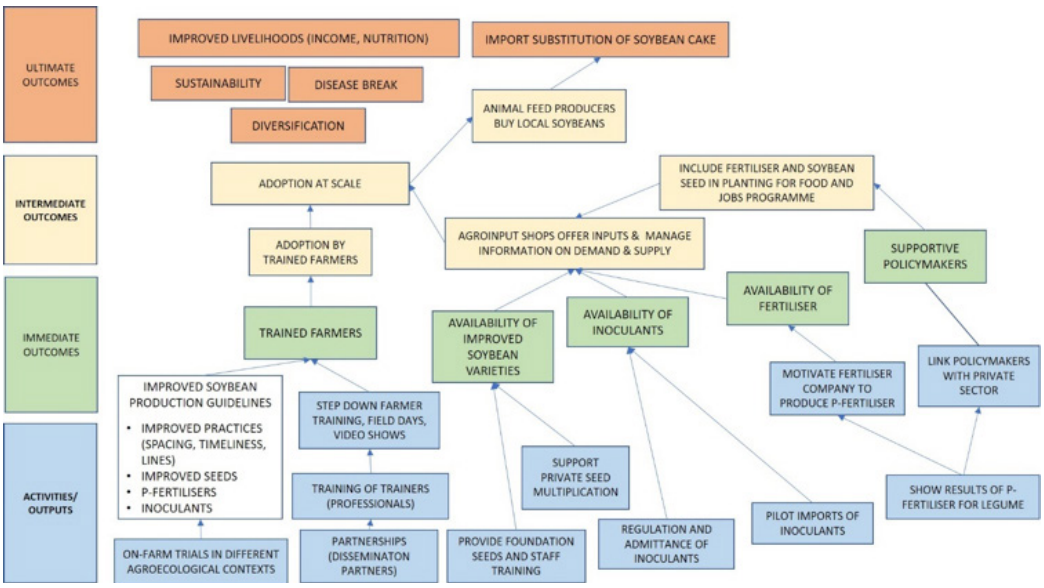
In a workshop with all N2Africa country coordinators, we started with a reflection on the rationale behind N2Africa, leading to a refined Theory of Change with detailed impact pathways for the two cases. The impact pathways imply sets of interlinked assumptions about the immediate and intermediate outcomes that would need to be in place in order to have a fair chance to generate impact at scale.

2 Case 1 – Verifying the contribution claims of N2Africa related to soybean expansion in northern Ghana

This section discusses the evidence behind the contribution story of N2Africa regarding the expansion of soybean cultivation in northern Ghana. The contribution claims are clearly documented in *N2Africa Success Story: Putting Nitrogen Fixation to Work for Smallholder Farmers in Northern Ghana* (Dotse and Badu 2018). In the February 2019 workshop with all N2Africa staff, the work in Ghana was considered to have had impact at scale and contributed to the expansion of soybean production in the region.

The work in N2Africa's second phase (2014–19) builds on the technology development and validation work of an earlier phase (2009–13). It has a clear objective to increase the availability and adoption of nitrogen fixation techniques by smallholder farmers. The intervention logic that provides the framework for this contribution story is shown in Figure 2.1.

Figure 2.1 The Theory of Change of N2Africa contribution to soybean expansion in northern Ghana



Note: Revised version of the figure discussed in the February 2019 N2Africa workshop.
Source: Authors' own.

Figure 2.1 depicts five interlinked impact pathways with their respective immediate outcomes in green. It shows: one pathway related to training; three related to technologies (seeds, inoculants, fertiliser) that are used in a farmer-to-farmer process of adoption and diffusion; and a fifth pathway to create a favourable policy environment of subsidies in the Planting for Food and Jobs Programme to facilitate the adoption of the technologies by smallholder farmers. It is also clear that N2Africa is well aware that the five pathways are meant to work in combination, making it a synergetic process of change.

We reviewed the evidence base behind the contribution claim: 'N2Africa has been a relevant contributory factor in the expansion of soybean production in northern Ghana'. We differentiated four assumptions that underpin the contribution claim, more or less aligned with the links between the activities, immediate outcomes, intermediate outcomes and ultimate outcomes in the Theory of Change (Figure 2.1), and verified whether these were in fact delivered, and what the importance of N2Africa has been on each of these.

- Critical assumption 1: Soybean production in northern Ghana is expanding.
- Critical assumption 2: N2Africa-recommended technologies are used by smallholders.
- Critical assumption 3: N2Africa-recommended technologies are available to smallholders.
- Critical assumption 4: N2Africa-recommended technologies can improve yields and incomes.

2.1 Critical assumption 1: Soybean production in northern Ghana is expanding

Soybean production existed in northern Ghana well before N2Africa started, but as a minor crop only, mixed-cropped with maize. Soybean was introduced in smallholder agriculture in the 1980s, first mainly as a fodder crop and gradually incorporated as a minor crop for human consumption. In 2005, a study by the Overseas Development Institute (ODI) mentioned that two companies buy soya from farmers organised by non-government organisations (NGOs):

> Oilseeds are promising both for the internal market and, if enough can be produced, for export. Soybean, in particular, seems capable of expanding as a commercial crop supplied to oil mills, where it is difficult for mills to get enough groundnuts as these are in heavy local demand. There has been significant growth in soybean production, encouraged by some NGOs. Both soybeans and groundnuts are both food and cash crops, and therefore very attractive to farmers. Both contribute nitrogen to farming systems. A first step in expanding production for the market would be the organisation of a producers' association (which could be oilseeds or crop-specific).
> (Shepherd *et al.* 2005: 32)

The establishment of the processing industry (Ghana Nuts, Bosbel Oil Industries) around 2004 was a decisive factor in positioning soybean production as a cash crop in smallholder farming systems. In the farmer diet, soybeans were specially used for the preparation of *dawadawa* (a fermented food condiment originally made from the locust bean tree but nowadays increasingly made from soybeans). The uptake of soybean as a cash crop is facilitated by the fact that it has some advantages over other crops, like maize and groundnut. Soybeans are procured year-round by agents that deliver to the oil processors, and can be stored without much post-harvest loss during several months inside the farmhouse. Therefore, farmers do not need to sell all their produce immediately after harvest. According to the interview with Joshua Nyaaba of the Evangelical Presbyterian Development and Relief Agency (EPDRA)-Yendi, farmers tend to sell around half of the harvest at harvest time to pay for the outstanding loans used for production (and also for school fees or other expenses), and sell the other half spread across the months before planting. According to Yara Ghana, due to the possibility to save soybeans in-house until planting time, soybean production may develop as an important source of cash for smallholders to buy fertiliser for maize.

Data on regular soybean production in northern Ghana are notoriously unreliable according to N2Africa staff, though all interviewees (see Annexe) believed that there has been an expansion of soybean production. In the absence of fine-grained official data (e.g. Mohammed, Al-hassan and Jatoe 2018), there are supportive indirect indications of this expansion, especially through the increased domestic supply of soybean to processors, and growing exports of soybeans (to Turkey). Based on interviews with the biggest oil processors, N2Africa and the International Institute of Tropical Agriculture (IITA) (Baars pers. comm.) estimate that the local production of soybeans in Ghana in 2018 was (at least) 170,000 metric tons, with ample potential for growth.[2] The report estimates that in the same period, a similar quantity of soy-derived products (grain equivalents) was imported, suggesting ample room for growth.[3]

2.2 Critical assumption 2: N2Africa-recommended technologies are used by smallholders

N2Africa aims to increase the availability of three types of technologies to farmers: seeds, inoculants and fertiliser. All three technologies need to be bought from the market, though seeds can last several years before they need to be replaced. Overall, farmers do not use many external inputs in soybean production, except

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2 The data do not permit distinguishing between smallholder or large farmer production. Nevertheless,we can make some rough calculations of the upper bound of the number of smallholder farmers involved in soybean production. Considering a total production of 170,000 tons, the average smallholder plot size as 0.5 ha, with a yield 850 kg/ha,$^{-1}$ this would give an upper limit of 400,000 smallholders in northern Ghana that may be involved in soybean production. The number of farmers that received direct training on the N2Africa ‘technology package’, estimated at around 2,000 in 2017, is relatively small compared with the number of farmers involved in this soybean expansion.

3 An unintended negative outcome of the mechanised expansion of soybean production may be the potential soil degradation of the Savannah area. Most interviewees do not mention this as being a problem. The relatively low density of trees in the Savannah region might preclude seeing deforestation as a serious effect. This has also been the case in the Chaco region in Latin America where forested areas were converted for large-scale soybean production in Argentina, Paraguay and Bolivia (Hecht 2005).

for land preparation. Amanor (2019) shows that tractor services and herbicides are the norm in most smallholder farming systems in northern Ghana but fertilisers and certified seeds are rarely used in crops other than maize and rice. The very low use of external inputs in legumes (groundnuts, soybean) is partly because these crops are less responsive to fertiliser than maize is. Farmers have the perception that legumes fix their own nitrogen and therefore do not need mineral fertiliser. This is also partly a result of the fact that they are planted later than other crops on the farm, at a moment when cash is (even) more constrained.

The agricultural cycle in northern Ghana is based on one crop per year, often with a crop rotation of yam, groundnuts, maize and soybean,[4] using multiple plots. Planting is sequenced; first, farmers plant the yam, groundnuts and maize, and later in the season they plant soybeans. The decision to buy legume-specific inputs is, therefore, made when (large) parts of the cash or credit available to a farmer have already been used for inputs for other crops, especially maize. This drives non- and partial adoption of the N2Africa proposed technologies. This higher preference of input use for maize and the application of incomplete input packages for soybean production is supported by Hoppenbrouwers (2018), who analysed the risk preference of farmers and the use of mineral fertilisers. He concludes:

> I find that usage of high-cost inputs is low... Furthermore, I find that usage of complete technology packages is often unprofitable under specific circumstances – although this is highly context-dependent. When farmers adapt technology packages, leaving out mineral fertiliser, inoculant or both, the profitability estimates are financially more beneficial in some cases. Adding inoculant always increases profit or decreases loss. (Hoppenbrouwers 2018: iii)

The improved soybean seed varieties are widely used in Ghana, though farmers do not buy new seeds every year. Our own interviews with the farmers' group Taaganoba Tibigangso Farmers Union in Yendi indicated that they preferred renewing their soybean seeds every four or five years. They explained this as a rational decision to lower the cash expenses compared to the (perceived) yield effects of using new, certified seeds compared with self-saved seeds. The Gender and the Legume Alliance (Musebe, Njuge and Silvestri 2018: 9) documents the widespread adoption of improved soybean varieties:

> Notably, farmers are not necessarily growing their preferred seeds – they may have very limited choice. Due to the shortage of seed in the formal system, they buy grain in the markets and store seed year on year... Most farmers were using improved varieties promoted during the CABI-led 2017 and 2018 campaigns, describing them as less-shattering and high yielding. Jenguma, a cream variety which is tolerant to Striga and bacterial pustule was the most popular among all categories of farmers. All the male youth reported growing Afayak, a yellow-coloured improved variety which is also tolerant to cercospora leaf spots in addition to having similar traits to Jenguma.

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4 Personal conversation with Imogen Bellwood-Howard (IDS).

The adoption rate of the inoculant technology at the N2Africa operational sites was (self-)reported as 5,600 farmers. Even when farmers show a preference for cash investments in inoculants above legume fertiliser or seeds, access to inoculants remains a bottleneck. For example, the study by the Centre for Agriculture and Bioscience International CABI (Musebe *et al.* 2018: 14) indicated that in their research areas:

> There were no farmers using inoculant in either year [2017 and 2018], citing availability issues. Majority of farmers had learned about the application of inoculants and its benefits, mainly from radio programs, village-based film screenings, extension agents and demo plots through the ADVANCE project. Nevertheless, access and availability had greatly hindered trialing and adoption of this technology.

Overall, we see that the use of the N2Africa-promoted technologies by smallholder farmers is still incipient. The diffusion of the technological innovations in soybeans by farmer-to-farmer interactions is constrained by the lack of cash (fertiliser) and distribution channels (inoculants), while only the use of improved varieties is at a large scale, with N2Africa contributing to the offer of certified seeds to farmers to renew their seeds periodically. Without the government subsidy system (the Planting for Food and Jobs (PFJ) programme), only the impact pathway related to seeds is really at scale. The adoption of inoculants seems largely restricted to outgrower groups or farmer associations that can link demand and supply of inoculant outside the normal agrovet system (Avea *et al.* 2016). Fertiliser seems to be used rarely, though likely more often than inoculants due to availability issues, but mainly by larger farmers and smallholders that can get it through the input subsidy programme or outgrower schemes. Outgrower schemes around certified seed production will use many more technologies than groups that produce soybean as fodder or food crop, because the requirements and prices are more conducive.

2.3 Critical assumption 3: N2Africa-recommended technologies are available to smallholders

N2Africa claims that by 2017, it had helped establish five input distribution centres working with more than 14 local partners through public–private partnerships (PPPs) to increase farmers' access to legume inputs including rhizobium inoculants, phosphorus fertilisers and certified seeds. Considering reach and scale, the most prominent partnership is the one with Yara Ghana Ltd.

Yara is a large fertiliser company headquartered in Norway. N2Africa collaborated with Yara through field trials to evaluate the benefits of triple superphosphate (TSP) in grain legume production. As a result of successful field trials, Yara Ghana produced and distributed a legume-specific fertiliser (Yara Legume) in retail shops in northern Ghana for purchase by farmers, which resulted in a sale of about 200 tons in 2016. In 2017, according to N2Africa, Yara sold about 2,500 metric tons of the New Yara blend, packaged in 50kg bags to about 15,000 farmers. Almost all of this fertiliser ('90 per cent', according to Mahamah Abdul-Rahaman of Yara Ghana Ltd) was sold under the Ghanaian government's flagship PFJ programme in the 2017 cropping season. Not all fertiliser was effectively distributed and used in 2017, especially due to delays and problems with quality in the (imported) soybean seed provided as part of the package, so part of it was transferred to the next agricultural cycle, reflected in lower volumes sold by Yara in 2018. In that year, Yara only supplied NPK (nitrogen/phosphorus/potassium) and the supply of legume fertiliser was given to another company called Chemico, which has been supplying another P-fertiliser (TSP).

Yara can make the Yara Legume fertiliser blend on demand but only when the demand is large enough. In 2018, the company produced almost 400 metric tonnes of Yara Legume, far less than the volume sold in the 2017 season (the company was not selected to provide fertilisers for the PFJ programme in 2018). This demand is still too low to make it part of the normal supply to the agrovet shops. According to the interview with Mahamah Abdul-Rahaman of Yara Ghana Ltd:

> *It entails a lot of logistical costs if we are distributing around the shops. When farmers do not buy, it will be a big cost for us [Yara] because you leave it in commission in the shops. And if it's not sold, it comes back to us. So we need to get assurance that the products will be bought before... When somebody orders it, we will produce it... Now the minimum order [to make the blend] is 45 metric tons*.

Yara tries to make it easier for traders to access Yara Legume fertiliser. Yara sees it still as a pilot, in which it invests in order to generate sufficient demand in the future:

> *Last year I brought in a consignment of 150 tons [to Tamale] to keep it closer... So I will do again this year, and those who want can pick up, at least 4–5 metric tons*.

We can conclude that the N2Africa activities have contributed to a process that has made Yara Legume available to smallholders, but only on a pilot scale – not yet part of the regular input distribution system. Smallholders therefore still have only limited access to Yara Legume, and that access has been almost exclusively provided through the PFJ programme.

We noted earlier that the adoption of the improved seed varieties is already at scale. At the start of N2Africa, the improved soybean varieties were already present in the research institutes. N2Africa, however, played a major role in transforming the multiplication of these varieties in a way that it could support this scaling process. The presence of N2Africa resolved several formal requirements for the company Heritage Seeds that allowed it to increase the volume of certified seed it could produce, especially the regulation that required the presence in the seed producing farm of an agronomic expert in seed production. Due to N2Africa's partnership with Heritage, the government allowed Heritage's expansion of soy seed production through outgrower contracts with smallholders. Smallholders could be used to provide the land and labour required for seed production at a scale that Heritage could not manage alone. Currently, several organised smallholder groups multiply seeds, as outgrowers, that Heritage can package and sell with the formal seed certificate. The distribution system of certified soybean seeds is in place through the normal agrovet system, and many smallholders buy it to renew their stock.

The third element of N2Africa technology, inoculants, is not part of the input package provided by PFJ. Several interviewees indicated that smallholders would like to use inoculants when available. The N2Africa project formed a PPP with a private company, Green-ef, for the registration, importation and sale of inoculants in Ghana. In partnership with N2Africa, Green-ef trained more than 50 agro-inputs dealers within the regions that the project was working in. The technical training included understanding what the inoculant does and how to store it properly. Cooling is recommended to extend shelf life, though this creates a hurdle to effective distribution in rural areas. Agro-inputs shops located outside the cities need to take a risk when stocking inoculants that might not be sold directly (the same year). Therefore, it seems that in remote areas, inoculants will be supplied only to farmer groups (e.g. outgrower schemes) that can organise demand with reliable estimates of the volume of inoculants needed and payment modalities that reduce the risk of default.

Access to inoculants is still largely restricted to groups that are organised in associations or cooperatives, or directly supported by development NGOs. Many of these groups are soybean seed producers, with a good internal organisation for distribution of inputs and cash advances. Adoption at scale, outside these groups, seems almost absent. The development of inoculants with a longer shelf life may be one of the necessary conditions for adoption at scale, next to effective buy-back arrangements between the inoculant producer and the agro-input shops for unsold packages.

2.4 Critical assumption 4: N2Africa-recommended technologies can improve yields and incomes

N2Africa has done much research on the effectiveness of the recommended technologies. There is general agreement that all three components (seeds, fertilisers and inoculants) are financially sound investments under average agronomic conditions. The ‘average conditions’ are, however, not always present, and mask the reality of unreliable weather and differing soil qualities on smallholder plots. Thus, even when on average a technology is profitable, there are always financial risks which explain (partial) non-adoption of one or more of the technologies on offer.

The main issue addressed by N2Africa with the work on certified seeds was the availability of improved varieties to smallholder farmers. These varieties are less vulnerable to yield losses caused by poor germination or pod shattering. Pod shattering makes the timing of the harvest very critical, while this was difficult to be reconciled with other activities on the farm. The improved varieties give farmers more flexibility in their use of labour during the soybean harvest, considering that they have to care for multiple crops at the same time. There is convincing evidence in the interviews with key informants that N2Africa helped to establish community seed multiplication systems in a way that can produce sufficient improved seeds for the expanding area of soybean production.

As described earlier, farmers indicated that they get yield benefits of improved varieties for several cropping cycles, without the need to buy certified seeds every year. Farmers will still benefit from the improved varieties using early generations of self-saved seed (or obtaining these from neighbouring farmers). More research on the yield effects of certified seeds compared with first- and second-generation farmer-saved seeds could help to understand this practice, and verify whether the recommendation to buy certified seed every season is valid. When this research shows that early generation seeds maintain most of their characteristics, strengthening the capabilities of farmers to select and save seeds, and promoting (early generation) seed exchanges in rural areas (Richards 2007) could be promising pathways to create (and attribute) more impact at scale from the seed multiplication efforts.

The training material on inoculant use states that 'There is a yield increase that more than pays for the input costs of inoculants itself'. Most farmers and technical staff interviewed corroborated this statement. However, the data on this are somewhat contentious, with authors using widely different values for the price of inoculants and the average yield effect.[5] Moreover, Ulzen *et al*. (2018: 31) writes that:

> The agronomic approach adopted for determining responsive and non-responsive sites indicated that a large majority of the fields were non-responsive to P and / or I. Only 17–40% of the study fields in the Northern region were responsive while 6–17% were responsive in the Upper West region.

This suggests that the application of inoculants is not always cost-effective. Also, Samuel Adjei-Nsiah of N2Africa indicated that there is no research yet to determine whether the use of inoculants in preceding seasons could have legacy effects and make it less opportune to apply it year after year on the same plot. There is little known about the legacy effects of rhizobium that has established itself in the soil.[6] Van Heerwaarden (pers. comm. 2019), based on data from 2011 from northern Ghana, shows an average effect of inoculant use of 197kg ha^{-1}, with a confidence interval (95 per cent) of 106–287kg ha^{-1}. This shows that overall, inoculants are a (cost-)effective technology, though it would be beneficial if N2Africa were to collect more and better data on the yield effects and cost-effectiveness of the partial adoption of the promoted technologies (Ronner *et al.* 2016). When communicating with farmers/trainers, N2Africa could use an interval instead of a point estimate for the average yield and income effects that can be expected from applying the technology. The (enhanced) N-fixation by soybeans is available for subsequent crops. Therefore, the beneficial effects of soybean seeds and inoculants will be a higher yield of the subsequent crop. There is, however, lack of research evidence on these subsequent yield effects.

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5 According to Wellspring (2019), at current soybean prices (US$0.42–0.58 per kg-1) the net gain for farmers in Ghana with 0.5 ha soybean with inoculants is estimated at 300kg/ha^{-1} and provides a net benefit of US$30–45. This calculation seems at odds with reality, mainly because the yield effect used is much higher than reported in other studies (Adjei-Nsiah *et al.* 2019; 2018; van Heerwaarden *et al.* 2018; Lamptey *et al.* 2014), which are between 150 and 200kg/ha^{-1}. Simple arithmetic with those lower yield estimates suggests an evaporation of the net benefit: 100kg less yield represents a value of US$42–58. Adjei-Nsiah *et al.* (2018) argue that inoculants are a good investment even with lower prices and lower net-yield effect, but use a cost of rhizobium inoculant of US$12.50 ha^{-1}. The cost of inoculants needed for proper inoculation in this study is, however, lower than suggested by the interviews (estimated to be close to US$20 ha^{-1}.

6 Interestingly, the presence of local rhizobium strands in soils is used in some studies to explain disappointing test results of the inoculant trial (Ulzen *et al.* 2016).

Instead, there is ample evidence about the positive yield effects of mineral fertiliser on soybean yields. N2Africa's fertiliser trials with varying phosphorus sources and dosage convinced Yara to increase the amount of phosphorus in their NPK blend, developing the special fertiliser Yara Legume. Yara refrained from offering TSP fertiliser to farmers, though initially this was recommended by N2Africa, but instead included other micro-nutrients largely due to the experiments and recommendations from its headquarters in Norway. The Yara marketing manager in charge of northern Ghana was explicit in mentioning the positive influence of N2Africa in this process of developing Yara Legume, though he also indicated that these trials also fitted quite neatly in the research and development (R&D) trials that Yara routinely plans to develop and test new products for specific crops.

The interviews with N2Africa staff showed that there are different perspectives regarding the optimal timing of application of phosphorus fertiliser. Perhaps agronomic reasons prescribe application before the planting, but there are strong risk management reasons to wait until the plants have established themselves. The risk of losing the investment made in inputs due to failing crops is quite high in agricultural conditions with droughts, late rains or short growing periods. Moreover, farmers' first priority (not just for time use but also in the importance attached to the crop) is the application of fertiliser to maize. This situation creates a context where it is unlikely that many farmers will adopt fertiliser application to soybeans at scale. Even where Yara Legume is commercially available in rural agro-input shops, at the moment of deciding whether to buy, most of farmers' scarce cash would already have been spent on the inputs for earlier and more important crops.

It is widely recognised that N2Africa played a key role in convincing regional and national policymakers to include the new fertiliser blend, Yara Legume, as one of the options for farmers in the PFJ inputs subsidy programme. The explicit mention of soybeans in the eligible crops for the programme created a large market for the certified soybean seeds and opened a distribution venue for the Yara Legume fertiliser. Nevertheless, within their mixed farming activities, most of the smallholders register in the input subsidy programme to obtain inputs for maize, not soybean.[7]

2.5 Conclusion

There is convincing evidence of a fair contribution of N2Africa to a process of technological upgrading of soybean production that, as yet, still only weakly influences the increase in soybean production in northern Ghana. Most of the growth in soybean production seems to result from crop area expansion by smallholder farmers, with relatively low yields and limited use of external inputs, especially fertiliser and inoculants. Smallholders cultivate soybeans as part of a mixed cropping system in which they prioritise cash use for external inputs for maize, not the N2Africa-promoted technologies for soybeans.

Reviewing the hoop tests in relation to the overall contribution claim, we draw the following conclusions.

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7 Using NPK fertilisers on maize may have a P residual effect for soybean in rotation. Less than through direct application, but also less risky – costly and with a higher chance of being profitable.

1. Did the soybean expansion take place?

   Yes. Though data are unreliable, most interviewees believe that there was an expansion of soybean production in northern Ghana. This is considered as a positive development.

2. Was N2Africa support used in the process?

   Yes. The seed multiplication in particular is likely to have had a positive effect on soybean yields of a large number of smallholder farmers. These farmers use certified and early-generation seed of the improved varieties.

3. Was N2Africa necessary to speed up or scale faster?

   Yes. The seed multiplication work has had a positive systemic effect for the availability of quality seed for smallholder farmers. The impact of the work on inoculants and fertiliser is, however, still fairly limited. Uptake seems largely restricted to groups of farmers that are self-organised or benefit from NGO support, where the demand and supply of inoculants and fertiliser is being registered and communicated to the agro-input shops, and where uptake is facilitated by pre-harvest loans.

   N2Africa played a facilitating role in opening up the PFJ programme to legumes. Legume fertilisers are increasingly available but still in a 'pilot distribution mode' by Yara, not part of its regular distribution system. The quantities that are demanded are too small to make it part of the regular stock in the agro-input shops. The PFJ has been the most important driver of demand for the legume fertiliser. N2Africa has contributed to the availability of other P-fertiliser in the PFJ. However, the PFJ creates a somewhat artificial market that may collapse when the subsidies are discontinued.

   Due to the relatively short shelf life of inoculants, these are only available through networks and partnerships and not yet a normal part of the basket of options available to farmers in remote, rural areas.

   The positive effects of the three promoted technologies (certified seeds, inoculants, P-fertiliser) are well-demonstrated, though data on costs and financial risks are sometimes inconsistent. More evidence on the cost-effectiveness of partial adoption strategies could help farmers to choose their options from the basket of available technologies (Ronner 2018; Ronner *et al.* 2016).

4. Was N2Africa a necessary causal factor for the expansion to take place?

   No. N2Africa cannot claim to be the trigger that started this expansion. The main trigger is the demand generated by the processing industries that started to be located in the area. At most, N2Africa played a facilitating role in a wide number of partnerships, involving many projects and initiatives, that accompany the efforts of smallholders to benefit from the increasing demand for soybeans in Ghana. Without N2Africa, this growth of soybean acreage would have started anyhow, and will continue, but likely with an even lower adoption of fertiliser and inoculants.

3 Case 2 – Verifying the contribution claims of N2Africa related to the adoption of legume inoculants by smallholders in Ethiopia

This second case study examines and discusses the quality and quantity of evidence supporting the claim that N2Africa contributed substantially to the expansion of supply of, demand for and use of legume inoculants by smallholder producers in Ethiopia. The contribution claims are documented in N2Africa's annual reports and the programme's impact evaluation report (Ampadu-Boakye, Ronner and Kanampiu 2018a; Ampadu-Boakye *et al.* 2018b; Wolde-Meskel 2019a; Dontsop and Ampadu-Boakye 2019). The work in Ethiopia is considered an example of positive impact by N2Africa, because it shows a contribution to the development of a new input-supply sector for legume inoculant technologies in the country.

Ethiopia joined N2Africa during the project's second phase (2014–19). The overarching project has a clear objective to increase the availability and uptake of nitrogen fixation inputs and methods by smallholder farmers. In particular, N2Africa

Box 3.1 N2Africa in Ethiopia

Ethiopia joined the N2Africa project in phase 2 (2014–19) as a 'core country'. N2Africa in Ethiopia focused on improving production technologies and value chain linkages for four legumes: common bean, soybean, faba bean and chickpea. These legumes are cultivated principally by small-scale producers in Ethiopia. The production technologies promoted by N2Africa in the country included improved and locally suitable varieties, inorganic fertilisers (particularly phosphorus), and rhizobium inoculants that stimulate nitrogen fixation. The project also encouraged farmers to adopt recommended 'best management practices' such as intercropping, crop rotations and regular spacing of plants. Key activities included scientific field trials in several locations to identify high-yielding legume varieties and effective inoculant strains, local adaptation trials, and demonstration trials to introduce the technology to farmers.

The project was designed to be sensitive to gender issues in legume production and to promote women's empowerment. N2Africa in Ethiopia was coordinated through the International Livestock Research Institute (ILRI) from Addis Ababa, through a series of partnership agreements with research institutes, extension and training organisations, farmers' cooperative unions, private sector input manufacturers and suppliers, and grain buyers. Organisationally, the project operated through seven regional public–private partnership (PPP) clusters.

Sources: Various N2Africa project documents, annual reports and website.

in Ethiopia has focused on expanding the supply of rhizobium inoculants (mainly through domestic production and providing a regulatory framework for eventual imports) and increasing demand for the inoculants among smallholders as a way to increase the yields and productivity of legumes under Ethiopian farming conditions (see Box 3.1).

The intervention logic that provides the framework for the N2Africa contribution story in Ethiopia is shown in Figure 3.1. The figure makes it possible to trace the causal logic of N2Africa's contribution through four interlinked impact pathways, each comprising a number of activities, which may be summarised in simplified form as follows (Table 3.1).[8]

Table 3.1 The N2Africa Ethiopia programme

Pathway 1	Developing and promoting packages of improved chickpea inoculant technologies for different regions of Ethiopia • Activity 1.1 – Identifying best-fit combinations of legume variety × inoculant strain × site [research activity] • Activity 1.2 – Adaptation trials and demonstrations [promotion, extension activity]
Pathway 2	Stimulating private sector involvement in inoculant supply (production and potentially import; distribution and marketing) • Activity 2.1 – Capacity building of Menagesha Biotech Industry (MBI) (inoculant producer) [increasing quantity, improving quality of input production and supply, strengthening distribution systems] • Activity 2.2 – Working with local agrodealers [improving distribution and marketing]
Pathway 3	Building technical capacity of key actors in the legume sector • Activity 3.1 – Creation of PPP platforms for each regional cluster [networking, platform for cooperation and communication] • Activity 3.2 – Capacity building of National Agricultural Research System (NARS), universities, extension services, agrodealers [research, training activity]
Pathway 4	Influencing development of supportive policy frameworks • Activity 4.1 – Engaging with government officials and policymakers [advocacy and communications activity] • Activity 4.2 – Developing draft protocols and standards [technical advisory activity]

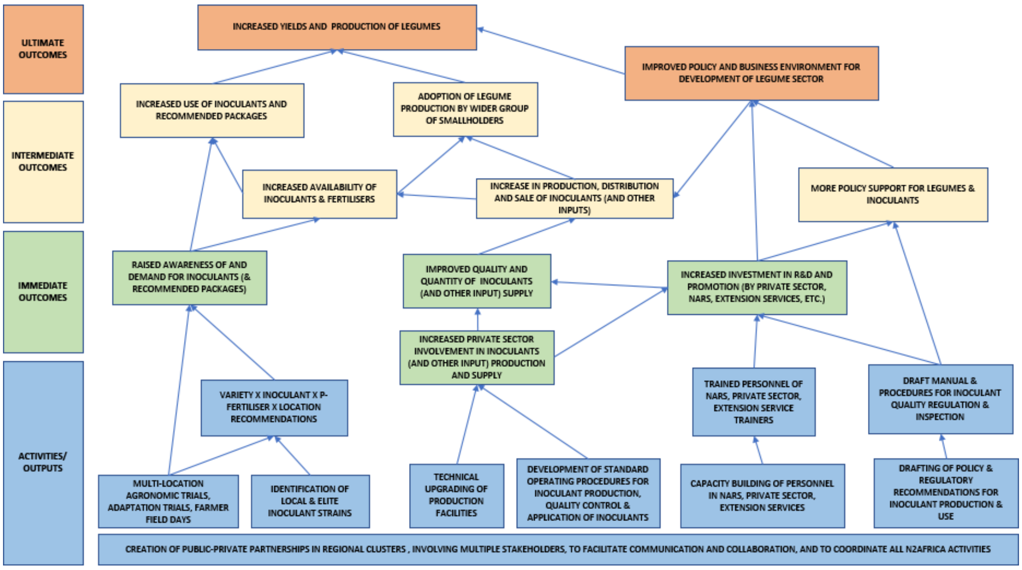
Source: Authors' own.

N2Africa documentation and key informants emphasised a number of key claims about the project's impacts. In particular, they stated that the project helped to increase the volume and improve the quality of legume inoculant production in the country, and boosted the volumes of inoculants distributed and sold to small-scale farmers. By identifying and promoting well-performing combinations of legume varieties and inoculants for specific production areas, and demonstrating

8 Note: These four impact pathways, identified for the purpose of this Contribution Analysis, correspond loosely to, but cut across, the four pillars of the N2Africa project, namely: capacity building, input supply, dissemination, and market access.

the improved yield performance of these technology packages to farmers, N2Africa claims to have raised awareness among both small-scale farmers and other actors in the legume sector of the effectiveness and economic viability of these technologies, thus stimulating demand. We reviewed the evidence behind the contribution claim: 'N2Africa has contributed to the increase in production, distribution, uptake and expansion of market demand for legume inoculants in Ethiopia'.

Figure 3.1 The Theory of Change of N2Africa's contribution to the expansion of inoculant technologies in Ethiopia



Source: Authors' own.

To investigate N2Africa's contribution, we verified whether the claimed changes took place and what contribution N2Africa had made to each of these. We used an approach informed by process tracing (Punton and Welle 2015; Beach and Pedersen 2013). Process tracing implies a structured way of deriving causal inference by critically reviewing the process and sequence of change. We verified the following three critical assumptions in the Theory of Change:

- Critical assumption 1: N2Africa support increased the demand for legume inoculants by smallholders.
- Critical assumption 2: N2Africa support improved quality and availability of legume inoculants in Ethiopia.
- Critical assumption 3: N2Africa enhanced the potential of inoculant technologies as a viable commercial opportunity for small-scale producers and other stakeholders.

N2Africa has produced, collated and published abundant evidence in documentary and other forms which attests to its activities, including handbooks and guidelines on experimental protocols and best practices, baseline studies, policy assessments and situation reviews, planning documents and progress reviews, and so on. This report seeks to understand whether this activity contributed to the achievement of the positive outcomes claimed.

3.1 Critical assumption 1: N2Africa support increased the demand for legume inoculants by smallholders

N2Africa claims that demand for and use of rhizobium inoculants by Ethiopian legume growers has increased strongly as a result of the project's efforts. The project partners undertook a range of activities to investigate the right technologies to recommend, to improve the supply of the recommended inputs, and to encourage farmers to take them up, along with new cultivation techniques. A survey of farmers conducted by N2Africa at the end of the project found high levels of awareness, usage and intention to continue using the project's key technologies, singly or in combinations of two, three or four elements. However, high levels of willingness to buy were matched by concern that the inputs might not be accessible, particularly once the project had ended (Wolde-Meskel 2019b; Dontsop and Ampadu-Boakye 2019).

Beginning at the research end, the first phase of the N2Africa project had already demonstrated that interactions among variety × inoculant × location were critical. Research was done by N2Africa to identify effective combinations of legume varieties, rhizobium strains and management practices for different cultivation environments. The resulting combinations were called 'best fit options'. Project researchers also assessed the availability and accessibility of legume varieties and related technologies, and analysed the sale and utilisation of legumes (Farrow *et al.* 2019).

Various informants described how the N2Africa project provided additional resources and focus to allow an increase in the intensity of promotional activities, to encourage legume farmers to take up new varieties, inoculants, fertilisers, and cultivation methods such as intercropping. Previously, research institutes and extension organisations had lacked the resources to promote these technologies effectively (interview 8 and others, see Annexe). Various interviewees, representing different organisations involved in N2Africa, affirmed that the introduction of inoculants constituted the most important new contribution made by N2Africa (interview 1 and others).

For example, a representative of Balegreen Spice and Grain Development (Balegreen), an agri-business company and commercial farmer, stated that neither his company nor the farmers it works with had really heard of inoculants before the N2Africa project introduced them. Retrospectively, he acknowledged that inoculant had been available in principle from the government's National Soil Testing Centre (NSTC), but neither he nor the farmers understood the beneficial potential of the technology (interview 4). An interviewee from an agricultural input dealership that was involved in N2Africa's Southern PPP cluster, Mirko Agrodealer, also noted that he had encountered inoculants for the first time when he met with a representative of MBI; prior to that encounter, he had known nothing about them. MBI demonstrated the product and he agreed to take on the dealership (interview 1). An informant from the Bureau of Agriculture confirmed that no farmers in his area were using inoculant until the N2Africa project came along (interview 13).

All three of these informants concurred that demand for and uptake of inoculants grew rapidly from nothing. According to the representative of Balegreen, both he and his outgrowers used inoculants initially to indulge the N2Africa staff, without a confident expectation of a good result. However, the positive effect on yield was very remarkable. As a result, he said, the smallholder farmers who produce chickpea for his company are not only using inoculant on his instructions but are now beginning to use inoculants on their own initiative (interview 4). Mirko Agrodealer began distributing inoculant for MBI in the Southern PPP cluster in 2015, with just 50 packets, but by 2019 the company was handling 5,000 packets (of which around 600 remained in stock at the time of our interview in May 2019). The Mirko representative explained that inoculants were particularly in demand among smallholders in highland areas, where there was sufficient moisture. In lowland areas, where there could be moisture stress, farmers did not always see any advantage from using inoculants; however, he opined that the farmers did not mind paying for the inoculants as the additional cost was small in proportion to the cost of seed. As a standalone product, he reckoned that inoculant could only be profitable if dealing in bulk, but with the small volumes he was handling at the moment, he regarded inoculant supply as more of a ‘social service’ than a commercially viable business. He saw inoculants as an item with commercial potential, and was interested in bundling the inoculant with seed as a means of product promotion (interview 1).

A farmer and chairman of a producer cooperative explained that the N2Africa approach had helped to raise farmers’ awareness about inoculants, as well as seed varieties and seed production and cultivation methods. He claimed that all the farmers in the Northern PPP cluster area of N2Africa were now using inoculant and had also adopted the recommended *kabuli* type of chickpea alongside the *desi* types they used to grow in the past. Although the investment and effort involved in using the new technologies was greater, the extra effort was rewarded at the end of the season (interview 12). A representative of the Bureau of Agriculture in Gondar affirmed that farmers in his area had also adopted both inoculants and the new *kabuli* chickpea variety, Arerti (interview 13).

An informant from one of the universities involved in N2Africa stated that smallholder farmers had believed that pulses could be grown without external inputs, but demonstrations of the impacts of inoculants and legume fertilisers in combination with improved varieties convinced them that these inputs were valuable. In fact, the same informant argued that even researchers from the public agricultural research institutes had typically grown pulses without external inputs, and that their behaviour had also changed as a result of N2Africa’s activities (interview 6).

An informant from Catholic Relief Services (CRS) stated that, through his organisation, 20,000 farmers had used inoculant technology, rising from only 200 in 2015 when CRS first formed its relationship with N2Africa. The *woredas* (districts) covered by CRS’s Farmer-to-Farmer project overlapped only partly with one of N2Africa’s PPP cluster areas, so that much of the impact from CRS’s reach was additional to N2Africa’s reach (interview 3).

In spite of these positive assessments of the impact of N2Africa on raising awareness and increasing demand for inoculants and other technologies, MBI’s own data (collated by N2Africa) suggest that actual uptake of inoculants is far below 100 per cent of farmers in the project’s cluster areas. Meanwhile, multiple informants expressed concern about the ongoing sustainability of these developments now that the project has come to an end.

Various interviewees agreed that the inoculant business has huge potential to grow in Ethiopia and to have a positive impact, but at present it is fragile, 'like an infant' (e.g. interview 8). A representative of Tsehay Farmers' Cooperative Union – part of the Northern PPP cluster – claimed that their union alone had 120,000 members seeking inoculants, yet N2Africa's data on the distribution and sales of inoculants across the entire project imply that usage in the whole of the Northern cluster is far short of that (see below). This informant explained that the problem had to do with logistical issues and matching supply to demand in a timely fashion. He said that farmers typically left it until planting time to place their inoculant orders with the union, but the company (MBI) could not supply the product at such short notice. Neither the union, nor the local agrodealers, nor MBI was willing to stockpile the product close to the market in anticipation of demand. The union's traditional priority in terms of bulk purchasing on behalf of its members was to procure chemical inputs; for MBI, the problem was that the company lacked the financial and other resources to produce inoculant speculatively and stockpile it in large quantities, not forgetting the issues of storage and shelf life (interviews 2, 10 and others).

Various informants expressed concerns over whether the project's achievements would be sustainable now that the project had come to an end. One agrodealer pointed out that, within the framework of the N2Africa project, MBI had offered him a 50 per cent discount on the wholesale price of inputs, and allowed his company to take 25 per cent of their stock on a sale-or-return basis, reducing his risk (interview 1). Another interviewee felt that N2Africa had achieved a big impact in just a few years, and that the momentum would continue, but necessarily at a slower pace unless the government or another influential actor steps in to support the production and supply of inoculants and other inputs (interview 3). There must be some doubt about whether the progress achieved to date can be sustained.

N2Africa claims that its activities built demand for and use of inoculants and other legume production technologies, not only through its work in support of inoculant producers but also through its creation of the PPP regional cluster model of organisation and related efforts to build the capacity of various players involved in the legume sector (Wolde-Meskel 2019b). Multiple interviewees affirmed that the PPP organisational model was a novelty that made a big difference. Informants said that the PPPs were a platform for communication and cooperation that had not existed before. In particular, the PPP clusters were reported to have connected for the first time various organisations that had not collaborated or cooperated previously, including private sector enterprises, public agricultural research institutes, universities, farmers' cooperative unions and the Bureau of Agriculture. This also meant working across the entire value chain – from research and input production via agrodealers and farmers' cooperatives to legume growers and export buyers.

Our informant from GUTS Agro Industry mentioned that the PPP cooperative platform helped his company to mitigate the risks of operating in an environment where regulation and enforcement of contracts could be unreliable. The PPP approach strengthened relations among stakeholders along the value chain in order to build trust, mutual commitment and confidence (interview 5).

Various informants expressed the desire that this form of communication and mutual engagement should continue beyond the end of the project, but with varying degrees of confidence that this would happen. Some informants expressed concern that, without funding, the cooperative PPP approach would not survive; others felt that the rapid turnover of staff in government organisations was disruptive to the continuity of relationships and working methods (interview 3 and others). However, one informant also noted that a separate project, Feed the Future (funded by the United States Agency for International Development (USAID)), had taken up the effort to promote legume inoculants in his region and was mobilising the existing N2Africa PPP platform for this purpose (interview 4).

A representative of the Bureau of Agriculture explained that, through N2Africa, he had learned about new approaches to agricultural extension, especially the new method of working with individual farmers on demonstrations and scaling up from there, rather than the conventional approaches to 'mass mobilisation' that relied principally on spreading information. He noted that the novel approaches used by N2Africa saved the time and increased the impact of extension workers, enabling them to support whole *woredas* much more effectively than they had been able to previously (interview 13).

Another novel approach was the N2Africa project's method of organising field trials and demonstrations on farmers' own land. For this purpose they introduced 'small packs', comprising sufficient seed and inoculant for a small 20m × 20m trial plot, packaged along with information and guidance for farmers on how to set up a trial planting alongside a control plot, so that any differences in performance could be compared. One informant regarded this as a cost-effective way to reach farmers more effectively than using traditional mass-exposure approaches, which would typically involve setting up larger demonstrations that would be managed by professional technicians (interview 11).

3.2 Critical assumption 2: N2Africa increased the quality and availability of legume inoculants in Ethiopia

N2Africa reports that the production, distribution and sale of legume inoculants in Ethiopia increased six-fold, seven-fold and 13-fold respectively between 2013 and 2016 (Wolde-Meskel *et al.* 2018). Production rose from 29,000 125g packets of inoculant in 2013 (the year before N2Africa in Ethiopia commenced) to 207,445 packets in 2018 (the project's final year) (Wolde-Meskel 2019a; Ampadu-Boakye *et al.* 2018a; 2018b; 2017). Each 125g packet is designed to inoculate seed for 0.25 ha of land, suggesting that production in 2018 would have been sufficient for 52,000 ha, if fully taken up by legume farmers. However, distribution and sales lagged considerably behind production in each year. In 2013, the inoculant manufacturer says that it managed to distribute 20,000 packets and sold 10,000, out of the total production of 29,000 packets. In 2018, N2Africa reported that nearly 145,000 packets were distributed and nearly 138,000 were actually sold, suggesting that inoculants were used on about 34,500 ha of land planted with legumes in that year (Wolde-Meskel 2019a).

N2Africa claims that its legume technologies, including inoculants, lead to higher yields and production compared to national averages. Project documents argue that the inoculants are affordable and their effect on productivity is large enough to represent good value for the additional cost (Wolde-Meskel *et al.* 2018; Wolde-Meskel 2019b).

Some research on rhizobium inoculants for the production of various legumes was carried out in Ethiopia before the N2Africa project began there (Samago, Anniye and Dakora 2018; Degefu, Wolde-Meskel and Rasche 2018; Beshir *et al.* 2015; Argaw and Mnalku 2017). Inoculants were produced in Ethiopia by the two public sector institutes, the NSTC and the Hollota Agricultural Research Centre (HARC), but on a small scale, principally for research purposes, and with both a limited capacity and an unclear mandate to scale up production on a commercial footing (interview 2). A new private enterprise, Menagesha Biotech Industry plc (MBI), was established in 2012 to produce and market rhizobium inoculant products in Ethiopia, but as a start-up company it struggled to secure finance and its capacity was very small. During its first two operational years (2013 and 2014), MBI managed to produce nearly 100,000 packets of inoculant without making a profit. Developing a market for its products was a struggle, as it lacked effective distribution channels.

Multiple interviews and other sources confirm that, at that time, there was no other production or import of legume inoculants in Ethiopia and that market demand was almost entirely absent, due to very low levels of awareness among farmers and agri-input dealers alike. Awareness of inoculant technologies was beginning to emerge in various quarters, but various informants stated that they had known very little about rhizobium inoculation for legumes before coming into contact with N2Africa (e.g. interviews 8, 12 and others). For example, a representative of CRS described how one of its in-country volunteers, an agronomist, had advised the organisation in his end-of-assignment report that farmers should use rhizobium inoculants to improve N-fixation in common bean. Prompted by his advice, CRS made contact with N2Africa and through the project with MBI, and began to procure and distribute inoculant packets to farmers. The intervention proved so beneficial that CRS incorporated inoculant promotion routinely into its activities, putting new legume growers in contact with MBI (interview 3).

Against this background, it is evident that the N2Africa project carried out research into the performance of legume varieties and rhizobium inoculants through a concentration of effort on the four legumes selected for attention in the country (Wolde-Meskel *et al.* 2018). Alongside this research, N2Africa offered essential technical support to MBI to prepare a business plan and submit a successful application to the Alliance for a Green Revolution in Africa (AGRA) under its Scaling Seeds and Technologies Partnership (SSTP). With this support, MBI secured a grant of just under US$300,000, which the company used to purchase manufacturing equipment and expand its capacity to produce chickpea inoculant (Ampadu-Boakye *et al*. 2017). The AGRA grant also financed the multiplication and delivery of improved chickpea varieties and fertilisers to 90,000 growers in the major chickpea areas of Ethiopia, alongside training of farmers and other stakeholders in the chickpea value chain. N2Africa served as the chair of the AGRA–MBI project's steering committee and provided direct support to MBI's marketing effort. This investment can properly be understood as additional funding that was leveraged by N2Africa, since the AGRA grant was additional to N2Africa's own budget and was only available to private sector enterprises (interviews 2 and 7).

While it is evident – from project documents, scientific publications (e.g. Wolde-Meskel *et al.* 2018) and testimony from interviews – that N2Africa stimulated and facilitated research to identify high-yielding combinations of crop varieties and inoculants, it is also relevant to note that the project's research effort was not necessarily decisive in selecting the combinations of cultivars and inoculant strains that would be promoted for different crops and growing areas. For example, the project introduced no new varieties or inoculants for soybeans. This is because soybean is an introduced crop in Ethiopia, for which commercial cultivars have been newly imported, and where there is no presence of locally specific rhizobium strains that have evolved a specialised symbiotic relationship with particular varieties of soybean. Some other legumes have a much longer history of cultivation in Ethiopia, and the N2Africa-sponsored research did achieve new scientific insights into the genetic diversity and geographical distribution of rhizobium strains that have evolved alongside particular varieties. One such crop is chickpea, for which at least one effective inoculant strain had already been identified in Ethiopia before N2Africa began its work.

According to Birhan Abdulkadir, one of the coordinators of the project, N2Africa identified and recommended for commercialisation two new inoculant strains that were not already present: one for faba bean and one for common bean. An informant from the Northern PPP cluster noted that his region was one where experiments had identified a particular inoculant strain suitable for faba bean, which was supplied to MBI. However, the company was reluctant to produce and market the new strain, as it considered the potential customer base too small a market niche to be profitably served (interview 11).

There is evidence that N2Africa made an important contribution in supporting the development of MBI. A company representative explained that the partnership with N2Africa benefited MBI in several important ways. In addition to the securing of the AGRA grant, the company extended its networks and raised its profile among regional research institutes and universities, the Bureau of Agriculture (the government agricultural extension service) and input distributors. MBI also made contact through N2Africa with an international NGO, SNV Netherlands Development Organisation, which it regarded as a very important contact for future collaboration. Through N2Africa, MBI was also able to accelerate the process of validating the effectiveness of inoculant strains for different legumes and regions, and it was also helpful for the company to have the quality of its products verified independently by the research institutes involved in the N2Africa PPP clusters. The company had also learned, from participating in the project, how to organise and facilitate farmer field days and demonstrations. This informant said that, thanks to N2Africa, the company's production, distribution and sale of inoculants had increased substantially. In short, the fledgling company's journey to becoming a stable and profitable business had been made easier and quicker, reducing the 'years of struggle' that they were facing on their own (interview 2).

While N2Africa's technical assistance to MBI has contributed to the improvement of quality in the production and distribution of inoculants, interviews revealed that there remains considerable anxiety over the risk that shortcomings in manufacturing, distribution and storage of inoculant products may undermine quality standards and reduce farmers' confidence in inoculant technologies (e.g. interview 6). Rhizobia are living organisms that require careful handling. Recent research has found that the performance, and particularly the shelf life of some commercially available inoculants in East Africa, falls below the standards advertised by their manufacturers (Balume *et al.* 2015). Maintaining the quality of inoculant products, both at the manufacturing stage and throughout the supply chain, is an urgent concern for MBI. A company representative estimated that it would take only two consecutive years of poor results for farmers to lose confidence in the inoculants (interview 2). N2Africa has sought to train distributors, extension workers and farmers to handle the product well. N2Africa representatives have also persistently urged the Ethiopian government to create and enforce adequate standards for the industry, not only through its encounters with government officials but also by drafting a manual of policies and procedures for inoculant quality manufacturing, inspection and monitoring. This draft document has been submitted to the Ethiopian government, but has yet to be endorsed and implemented.

N2Africa staff also believe that their example and their success in generating demand among farmers for rhizobium inoculant helped to stimulate the NSTC to increase its own production and distribution of inoculants, from around 11,000 packets produced in 2010–11 to nearly 90,000 packets in 2015–16 (unpublished NSTC data passed on by N2Africa). However, evidence that this increase was attributable in part to N2Africa is circumstantial rather than definitive.

3.3 Critical assumption 3: N2Africa strengthened the potential of inoculant technologies with legumes as a viable commercial opportunity for small-scale producers and other stakeholders

N2Africa claims that its activities have expanded scientific knowledge on rhizobium inoculants, demonstrated the productivity of inoculants for legume production, revealed a large unmet market demand for legume inoculants, and demonstrated the profitability and productivity of inoculant technologies in conjunction with legume cultivation in Ethiopia. In this area of claim-making, N2Africa is asserting that its work in the country has helped to establish the beginnings of a substantial commercial expansion of inoculant production and use, and improvement of legume production. The potential market demand for appropriate strains of legume inoculant could be over 6 million packets, based on a cultivated area under legumes of 1.6 million ha (Wolde-Meskel 2019b).

Alongside MBI, other private sector enterprises involved in N2Africa related that they were also grateful for the project's support in building their businesses. For example, the representative of an agricultural input dealer involved in one of the PPP clusters said that N2Africa had had a profound effect on his fortunes, raising him from a 'nobody' to a substantial businessman. He noted in particular that the Ethiopian government routinely focuses on farmers' cooperative unions, whereas N2Africa had created an opportunity for private sector entrepreneurs, such as himself (interview 1).

This area of claims expands the interest of this report beyond inoculants to embrace N2Africa's focus on the improvement of legume production in general, and its whole value chain approach. Another private sector informant, from GUTS Agro Industry, appreciated that the N2Africa approach of working throughout the value chain had made a positive difference to its business. As a result of the project, the company had: expanded into chickpea; got their outgrowers to use inoculants that are increasing production; developed new legume-based baby food products; and entered into a new business – legume-based animal feeds –

both as a way to make use of by-products from their existing production and as a channel to reprocess and re-direct baby food products that are reaching the end of their shelf life. This meant that the company was now involved in a number of complementary activities and product lines, enabling it to construct a more sustainable business (interview 5). As a company involved in contract farming of legumes as well as food and feed production, it benefited not only from the PPP model of collaboration with other stakeholders, but from improvements in the quality of both legume seed and post-harvest residues that could be used for livestock feed (Dejene *et al.* 2018; Belete *et al.* 2019).

A representative of Balegreen, another agribusiness company, opined that N2Africa had helped to put chickpea cultivation in the Bale zone of Oromia region on the road towards becoming a viable and sustainable business. The major new elements introduced by N2Africa were inoculants, as well as the PPP model of cooperation among various stakeholders. He noted that his firm first ventured into chickpea cultivation in 2012, but the yields were poor at first and the company had difficulty in finding a market for the crop because the region was not known for chickpea production. In 2013 the company continued chickpea cultivation with support from an ACDI/VOCA[9] project, which introduced a different chickpea variety and linked the producers to a buyer. During this period, Balegreen also experimented with mechanical harvesting and threshing. The yield improved but was still quite small. Yields improved further after N2Africa field trials, in which Balegreen got involved, identifying another new chickpea variety (Habru), which proved to be more disease resistant and responsive to inoculants. It also has a larger grain, which is in export demand, and N2Africa linked the producers to an export buyer. The new inoculants, in combination with the Habru variety, produced remarkable yields – even better (according to this informant) than wheat. As a consequence of these steps, the Balegreen representative considered that N2Africa had helped establish chickpea as an emerging commercial opportunity for growers in Bale zone, having reached a coverage of 172,000 ha in the current season (2019) and with the potential to expand even further in Bale and neighbouring Arsi zone (interview 4).

The same informant argued that nitrogen-fixing leguminous crops were vital in his area in order to improve the sustainability of agriculture as a whole. He pointed out that continuous cultivation of wheat would be unsustainable unless nitrogen could be replaced in the soil. He also felt that, thanks to N2Africa's demonstration of the viability of chickpea cultivation in the area, the government and other stakeholders were now displaying a more positive attitude towards chickpea; however, the government's chief focus remained on grain crops such as teff and barley (interview 4).

Notwithstanding these positive impacts, N2Africa cannot claim credit for fully establishing chickpea technologies and chickpea cultivation on a sustainable footing. The Balegreen informant praised the project for helping to build momentum, but the momentum is not yet enough to be self-sustaining. He noted that N2Africa had provided some inputs free of charge, which is unsustainable,

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9 ACDI/VOCA is an international development non-profit organisation based in Washington DC, USA. See www.acdivoca.org/.

particularly for a commercial enterprise like his. He estimated that the impact of N2Africa in Bale had been very local and Balegreen would not be able to produce further scaling by itself. However, the Feed the Future project had taken up the reins, retaining the PPP cluster model established by N2Africa and continuing the focus on chickpeas and inoculant technologies (interview 4).

3.4 Conclusion

There is clear evidence that N2Africa made an important, catalytic contribution to the development of a viable commercial production system and a functional value chain for legume inoculant production, distribution and sale in Ethiopia, and particularly the uptake of inoculants by small-scale legume growers. Reviewing the hoop tests, we conclude as follows.

1. Did the expansion of inoculants production and use take place?

   Yes. Both documentary evidence and the testimony of key informants confirms that the volumes of production, distribution, sale and use of inoculants have increased significantly, from a very low base. Demand among farmers for reliable inoculant products has also increased. However, all stakeholders agreed that the inoculant market remains far below its estimated potential.

2. Was N2Africa support used in the process?

   Yes. It is very clear that N2Africa's support was crucial, especially in two key respects. First, it played a direct role in securing funds to upgrade and expand inoculant production at MBI. Second, the PPP regional cluster model brought stakeholders into contact with one another and enabled them to work together in ways that had not existed before the project.

3. Was N2Africa necessary to speed up or scale faster?

   Yes. While actors in the system already aspired to develop and expand a market for legume inoculants, and to use new biofertilisers to improve and increase legume production before N2Africa began, the project played a catalytic, facilitating role that substantially helped to accelerate these processes. In particular, N2Africa's support was key in enabling MBI to prepare and submit a winning proposal to AGRA and the Bill & Melinda Gates Foundation (BMGF), through which they won a grant to expand their production facilities. There is also good evidence that the PPP model of collaboration among multiple stakeholders helped to accelerate progress in legume inoculant production, distribution and uptake.

4. Was N2Africa a necessary causal factor for the expansion of inoculant supply and use to take place?

   Likely, yes. While it is clear that the expansion of inoculant production and use would have been slower and less assured in the absence of N2Africa, it is very plausible that these developments might have been delayed indefinitely or prevented entirely without N2Africa's intervention. The AGRA/BMGF to MBI might have occurred without N2Africa's intervention, but the company acknowledged that it had relied very heavily on N2Africa's expertise to compile the successful bid. Similarly, the PPP model was hailed as a positive innovation that was introduced uniquely by N2Africa. Hypothetically, N2Africa's interventions might have been made by a different agency, programme or project, and in fact there were and are other organisations seeking to improve legume production systems. However, as far as we are aware, no other organisation was actually undertaking such work during the period when N2Africa was underway.

The question remains whether the capacity of MBI and other key players has attained a stable critical mass to expand the market using its own resources, and whether the productive collaboration of partners involved in N2Africa Ethiopia will continue now that the project has come to an end. Several of the key informants interviewed for this analysis expressed the desire to sustain the relationships they had developed with other players within the framework of the N2Africa PPPs, but also a concern that the incentive and capacity to collaborate would disappear without N2Africa to coordinate. Various informants called for greater support and commitment from government, but various other factors were also mentioned, such as access to capital and the need to invest in training and capacity building, particularly in key areas such as quality control, handling and storage of inoculants, and training farmers.

It is worth observing that N2Africa was not the only actor that has sought to develop the legume sector and promote legume technologies. There was some interest in legumes and inoculants before N2Africa came along and some of its work is being taken up by other projects now that N2Africa has ended. However, the available evidence does support the conclusion that N2Africa's strategic and targeted approach has made a strong contribution to the development and strengthening of legume production in Ethiopia.

Finally, it is worth observing that this report has focused on N2Africa's major claim to have contributed on the input and production side of the legume sector, particularly the improvement of capacity in the production of effective inoculants, the production and supply of improved seeds and fertilisers, and work with farmers to improve productivity on farms. However, these priorities cannot be pursued exclusively without ensuring that there are channels to market, driven by the demand of end-users domestically and internationally. Although some activities were carried out that focused on the downstream links of the value chain (including linking farmers to export buyers) and some work on domestic consumption and nutrition (e.g. food preparation training), the expansion and strengthening of the production system presented sufficient challenges in their own right and appear to have absorbed much of the project officers' attention. In this area, some major challenges remain, including securing investment for the further expansion of inoculant production, improving quality, expanding distribution networks, and resolving bottlenecks in cashflow and logistics.

4 Discussion: the value of Contribution Analysis

A notable feature of this evaluation study was the degree of engagement and cooperation between the small evaluation team and the staff and stakeholders who had been involved in implementing the N2Africa project, especially the respective project teams in Ghana and Ethiopia. The study was not commissioned to be a detached and independent evaluation for the benefit of an external audience, but as an exercise in accompanied learning and reflection for the benefit of the project members themselves.

Key objectives of the evaluators were not only to evaluate the project as rigorously as possible, but also to demonstrate the methodology of Contribution Analysis and to show how it could be used by the N2Africa team themselves to examine and reflect on their own activities and achievements. The underlying motivation was to explore a way to learn effectively from the implementation of a project, in order to be able to extract and apply lessons to future activities. From this perspective, it was important for the project participants to learn about what worked well and what fell short of expectations; to reflect on the realism of the assumptions embodied in the project's Theory of Change and its specific impact pathways; to be rigorous in identifying the kinds of evidence that could underpin convincing impact claims; and to gather and collate this information so that a truthful and convincing impact narrative could be developed.

Contribution Analysis and process tracing use multiple data sources to evaluate impact similar to a courtroom session, and do not rely on one method of data collection to test whether an intervention works. It collects the evidence that supports the presence of the causal step and the evidence that could falsify it, and, as a result, gives an evaluation of the evidence presented. Ideally the three functions (attorney, barrister, judge) are taken up by separate persons or groups of people. However, real-world constraints made it necessary for us to take the three functions in one. The confirming evidence was largely presented by N2Africa teams in the initial stage of the research. To look for disconfirmative evidence, we explored the wider literature and interviewed persons that could be expected to have a more critical stance to the intervention. Finally, as judges, we reflected on both sources of evidence.

Contribution Analysis is meant to give a critical look, not to work towards a communication product that only presents the good sides of an intervention. The selection of cases took place during a workshop of all N2Africa country coordinators based on an inventory of cases where the participants expected to have contributed to impact at scale. The choice of overtly successful cases for the pilot of the approach made it difficult to find disconfirmative evidence, especially in the Ethiopian case. That is good news for N2Africa but also implies that it makes it quite difficult to show the main strength of the process tracing approach – searching explicitly for evidence to confirm or discard alternative explanations than N2Africa support. Generally, this external critical scrutiny helps to reconsider some causal links or refine the understanding of the causal process. Another challenge was the differences in the extent to which the contribution claim specified higher-level outcomes in the Theory of Change. When an intervention makes a bold claim, like in Ghana, disconfirming or contested evidence might be easier to find than when the contribution claim is more modest and realistic, as in the Ethiopian case.

A key benefit of Contribution Analysis is that when implemented carefully, it is capable of revealing outcomes and impact pathways that were unexpected. This makes it possible, for example, to reveal how the activities of other stakeholders may have helped the project to achieve its goals or expand its reach; or to discover some positive impacts of a project that were not anticipated in the original plan. Of course, it can also show how and why a project has fallen short of its objectives. In the case of N2Africa, key lessons include the fact that the project managed to achieve some positive impacts, but that there is doubt over whether its achievements will prove to be sustainable now that the project has come to an end. This, of course, is a very common predicament in the field of development projects. Contribution Analysis may make a positive impact here, if it helps project funders to see how heavily outcomes typically rely on stable institutional commitments, building strong relationships, and investing in initial successes.

Annexe: List of interviews conducted for this Contribution Analysis

Ghana

Interview number	Informant name	Organisation
1.	Joshua Nyaaba	Evangelical Presbyterian Development and Relief Agency (EPDRA), Yendi, Manager
2.	Mahamah Abdul-Rahaman	Yara Ghana Limited, Commercial Director, Northern Ghana and Burkina Faso
3.	Jalil Zakaria	2SCALE, Tamale, Country Team Leader
4.	Nana Osei Benji	X'Mart Marketing Links, Managing director
5.	Sachibu Mohammed	Green-EF Eco-Business Village Ltd, Chief Executive Officer (CEO)
6.	Samuel Adjei-Nsiah	N2Africa, Country Coordinator
7.	Eric Doe	N2Africa, Business Development Officer
8.	Abdul-Rashid Zakaria	Urban Agriculture Network, Executive Director
9.	Zakaria Sumani Iddrisu	Heritage Seeds, Managing Director
10.	Multiple (7 farmers)	Taaganoba/Tibigangso Farmers Union

Ethiopia

Interview number	Informant name	Organisation
1.	Mirko Shibru	Mirko Agrodealer
2.	Dejene Woldemariam	Menagesha Biotech Industry (MBI)
3.	Biruk Tesfaye	Catholic Relief Services (CRS)
4.	Million Bogale	Balegreen Spice and Grains Development plc (Balegreen)
5.	Engidu Legesse	GUTS Agro Industry plc
6.	Tulu Degefu	Hawassa University
7.	Yonas Sahlu	Alliance for a Green Revolution in Africa – Scaling Seeds and Technologies Partnership
8.	Kifle Degefa	Oromia Agricultural Research Institute, Bako Agricultural Research Centre
9.	Muleta Assefa	Bureau of Agriculture, Bako
10.	Endalkachew Abie	Tsehay Farmers' Cooperative Union
11.	Yonas Worku	Amhara Agricultural Research Institute (ARARI–Gonder)
12.	Wubetu Ayele	Farmer, Dembia
13.	Aragaw Tefara	Bureau of Agriculture, Dembia

References

Adjei-Nsiah, S.; Alabi, B.U.; Ahiakpa, J.K. and Kanampiu, F. (2018) 'Response of Grain Legumes to Phosphorus Application in the Guinea Savanna Agro-Ecological Zones of Ghana', *Agronomy Journal* 110.2: 1–8

Adjei-Nsiah, S.; Kumah, J.F.; Owuso-Bennoah, E. and Kanampiu, F. (2019) 'Influence of P Sources and Rhizobium Inoculation on Growth and Yield of Soybean Genotypes on Ferric Lixisols of Northern Guinea Savanna Zone of Ghana', *Communications in Soil Science and Plant Analysis* 50.7: 853–68

Amanor, K. (2019) *Mechanised Agriculture and Medium-Scale Farmers in Northern Ghana: A Success of Market Liberalism or a Product of a Longer History?* APRA Working Paper 23, Brighton: IDS

Ampadu-Boakye, T.; Ronner, E. and Kanampiu, F. (2018a) *N2Africa Annual Report 2017*, Wageningen: Wageningen University & Research

Ampadu-Boakye, T.; Ronner, E. and Kanampiu, F. (2018b) *N2Africa Annual Report 2018*, Wageningen: Wageningen University & Research

Ampadu-Boakye, T.; Ronner, E. and Kanampiu, F. (2017) *N2Africa Annual Report 2016*, Wageningen: Wageningen University & Research

Argaw, A. and Mnalku, A. (2017) 'Effectiveness of Native Rhizobium on Nodulation and Yield of Faba Bean (Vicia Faba L.) in Eastern Ethiopia', *Archives of Agronomy and Soil Science* 63.10: 1390–1403

Avea, A. *et al.* (2016) 'Do NGOs and Development Agencies Contribute to Sustainability of Smallholder Soybean Farmers in Northern Ghana – A Stochastic Production Frontier Approach', *Sustainability* 8.5: 465

Balume, I.K.; Keya, O.; Karanja, N.K. and Woomer, P.L. (2015) 'Shelf-Life of Legume Inoculants in Different Carrier Materials Available in East Africa', *African Crop Science Journal* 23.4: 379–85

Beach, D. and Pedersen, R.B. (2013) *Process-Tracing Methods: Foundations and Guidelines*, Ann Arbor MI: University of Michigan Press

Befani, B. and Mayne, J. (2014) 'Process Tracing and Contribution Analysis: A Combined Approach to Generative Causal Inference for Impact Evaluation', *IDS Bulletin* 45.6: 17–36, https://bulletin.ids.ac.uk/index.php/idsbo/article/view/139 (accessed 4 November 2019)

Belete, S. *et al.* (2019) 'Inoculation and Phosphorus Fertilizer Improve Food-feed Traits of Grain Legumes in Mixed Crop-livestock Systems of Ethiopia', *Agriculture, Ecosystems & Environment* 279: 58–64

Belkin, A. and Tetlock, P.E. (1996) *Counterfactual Thought Experiments in World Politics: Logical, Methodological, and Psychological Perspectives*, Princeton NJ: Princeton University Press

Beshir, H.M.; Walley, F.L.; Bueckert, R. and Tar'an, B. (2015) 'Response of Snap Bean Cultivars to Rhizobium Inoculation under Dryland Agriculture in Ethiopia', *Agronomy* 5.3: 291–308

Degefu, T.; Wolde-Meskel, E. and Rasche, F. (2018) ‘Genetic Diversity and Symbiotic Effectiveness of Bradyrhizobium Strains Nodulating Selected Annual Grain Legumes Growing in Ethiopia’, *International Journal of Systematic and Evolutionary Microbiology* 68.1: 449–60

Dejene, M. *et al.* (2018) ‘Variations in Seed and Post-harvest Residue Yields and Residues Quality of Common Bean (Phaseolus Vulgaris L.) as a Ruminant Feedstuff’, *Animal Feed Science and Technology* 244: 42–55

Dontsop, P. and Ampadu-Boakye, T. (2019) *Impact Evaluation Report of N2Africa Project*, Wageningen: Wageningen University & Research

Dotse, S.K. and Badu, A.-E. (2018) *N2Africa Success Story: Putting Nitrogen Fixation to Work for Smallholder Farmers in Northern Ghana*, Accra: International Institute of Tropical Agriculture

Farrow, A. *et al.* (2019) ‘From Best Fit Technologies to Best Fit Scaling: Incorporating and Evaluating Factors Affecting the Adoption of Grain Legumes in Sub-Saharan Africa’, *Experimental Agriculture* 55: 226–51

Hecht, S.B. (2005) ‘Soybeans, Development and Conservation on the Amazon Frontier’, *Development and Change* 36.2: 375–404

Hoppenbrouwers, M. (2018) ‘Usage of Agricultural Technologies for Soybean and Groundnut’, MSc thesis DEC-80433, Wageningen: Wageningen University

Lamptey, S.; Ahiabor, B.; Yeboah, S. and Asamoah, C. (2014) ‘Response of Soybean (Glycine Max) to Rhizobial Inoculation and Phosphorus Application’, *Journal of Experimental Biology and Agricultural Sciences* 2.1: 72–77

Mayne, J. (2011) ‘Contribution Analysis: Addressing Cause and Effect’, in K. Forss, M. Marra and R. Schwartz (eds) *Evaluating the Complex: Attribution, Contribution, and Beyond*, Piscataway: Transaction Publishers

Mayne, J. (2001) ‘Addressing Attribution Through Contribution Analysis: Using Performance Measures Sensibly’, *Canadian Journal of Program Evaluation* 16.1: 1–24

Mohammed, A-R.S.; Al-hassan, S. and Jatoe, J.D. (2018) ‘An Overview of Constraints to Soybean Production in the Northern Region of Ghana’, *UDS International Journal of Development* 5.1: 32–40

Musebe, R.; Njuge, R. and Silvestri, S. (2018) *Gender and the Legume Alliance: Integrating Multi-media Communication Approaches and Input Brokerage: A Report of Focus Group Discussions in Ghana*, London: CAB International

Punton, M. and Welle, K. (2015) *Straws-in-the-wind, Hoops and Smoking Guns: What can Process Tracing Offer to Impact Evaluation?* CDI Practice Paper 10, Brighton: IDS

Richards, P. (2007) ‘How Does Participation Work? Deliberation and Performance in African Food Security’, *IDS Bulletin* 38.5: 21–35, https://bulletin.ids.ac.uk/index.php/idsbo/article/view/818 (accessed 4 November 2019)

Ronner, E. (2018) ‘From Targeting to Tailoring: Baskets of Options for Legume Cultivation Among African Smallholders’, PhD dissertation, Wageningen University

Ronner, E. *et al.* (2016) 'Understanding Variability in Soybean Yield and Response to P-fertilizer and Rhizobium Inoculants on Farmers' Fields in Northern Nigeria', *Field Crops Research* 186: 133–45

Samago, T.Y.; Anniye, E.W. and Dakora, F.D. (2018) 'Grain Yield of Common Bean (Phaseolus Vulgaris L.) Varieties is Markedly Increased by Rhizobial Inoculation and Phosphorus Application in Ethiopia', *Symbiosis* 75.3: 245–55

Shepherd, A. *et al.* (2005) *Economic Growth in Northern Ghana: Revised Report for DFID Ghana,* London: Overseas Development Institute

Ton, G. (2017) 'Contribution Analysis of a Bolivian Innovation Grant Fund: Mixing Methods to Verify Relevance, Efficiency and Effectiveness', *Journal of Development Effectiveness* 9: 120–43

Ulzen, J.; Abaidoo, R.C.; Ewusi-Mensah, N. and Masso, C. (2018) 'On-Farm Evaluation and Determination of Sources of Variability of Soybean Response to *Bradyrhizobium* Inoculation and Phosphorus Fertilizer in Northern Ghana', *Agriculture, Ecosystems & Environment* 267: 23–32

Ulzen, J.; Abaidoo, R.C.; Mensah, N.E.; Masso, C. and Abdelgadir, A.H. (2016) 'Bradyrhizobium Inoculants Enhance Grain Yields of Soybean and Cowpea in Northern Ghana', *Frontiers in Plant Science* 7: 1770

van Heerwaarden, J. *et al.* (2018) 'Soyabean Response to Rhizobium Inoculation Across Sub-Saharan Africa: Patterns of Variation and the Role of Promiscuity', *Agriculture, Ecosystems & Environment* 261: 211–18

Wellspring (2019) *Inoculant 'Go to Market' Strategy (draft) – Inception Report*, Bristol: Wellspring

Wolde-Meskel, E. (2019a) *N2Africa Annual Report 2018 Ethiopia*, Wageningen: Wageningen University & Research

Wolde-Meskel, E. (2019b) 'A Walk Through the N2Africa-Ethiopia Project Implementation and Partnership Journey: Experiences on Legume Research, Dissemination and Input-Output Market Access', N2Africa – Ethiopia Project Closing Workshop, International Livestock Research Institute, Addis Ababa, 3 May

Wolde-Meskel, E. *et al.* (2018) 'Additive Yield Response of Chickpea (Cicer Arietinum L.) to Rhizobium Inoculation and Phosphorus Fertilizer Across Smallholder Farms in Ethiopia', *Agriculture, Ecosystems & Environment* 261: 144–52

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